SITE PLANNING AND VEGETATIVE PLANNING CRITERIA FOR COASTAL SHORELINE WETLAND VEGETATIVE ESTABLISHMENT

This Technical Note is intended to provide guidance in the determination of site characteristics and vegetative selection for the establishment of vegetation in areas of critically eroding or degraded coastal shorelines; wetlands; and estuaries; or to stabilize, protect, and/or vegetatively enhance areas of newly created shoreline, wetland or estuary, where one or more of the following conditions exists:

- The need to reduce plant mortality as a result of increased water depths due to soil subsidence and compaction;
- The need to protect shorelines and interior large water bodies from excessive scouring by wind and/or tidal surges from seasonal tropic and frontal passages;
- The need to stabilize plant community flux due to rapidly increasing saltwater concentrations;
- The need to accelerate vegetative establishment on newly accreted, loose, and unconsolidated sediment formations that have formed under natural geological or man-made processes ; and/or
- The need to increase plant density in areas of suspended sediments for the purposes of improving water quality and accelerating sediment accretion.

In Texas, coastal shoreline erosion has a significant effect on water quality in bays, and estuaries. Sediment from shorelines causes turbidity, inhibits phytoplankton production, covers oyster reefs, and fouls fish spawning areas. In addition it is a major source of sediment which increases the cost of maintenance of waterways. In Texas's coastal wetland environment, continued existence of marsh habitat is particularly dependent on the ability of the marsh to maintain its elevation within the tidal range through the process of vertical accretion. Several critical factors that influence the scope and rate of plant productivity and the effectiveness at which shorelines, wetlands, and estuaries can maintain themselves are:

Plant Species Adaptation

Consideration should be given to variability between plant species resulting from plant morphology (form and structure) and plant physiology (system processes). Consideration should also be given to genetic origin, propagule availability, and propagation requirements.

Soil Elements

Consideration should be given to a number of physical and chemical soil properties that can have a significant impact on the success or failure of a shoreline, wetland or estuary vegetative planting. Consideration should be given to the n-value, texture, pH, salinity, bulk density, and sulfidic material content of the soil at the planting site.

Hydrologic and Meteorologic Elements

Consideration should be given to the wave energy potential and the need for temporary or permanent wave damping devices. Additionally, water depth, velocity, duration, frequency of inundation, and level of salinity should be considered in developing project designs.

Geologic Elements

Consideration should be given to local subsidence and compaction rates, exposure to fetch lengths, availability of sediments, and surface and subsurface bank configuration.

Grazing and Nuisance Pressure

Consideration should be given to grazing pressures and nuisance damage from herbivores and the potential need for temporary structural protection from such damage.

Site Planning and Vegetative Planning Criteria for Coastal Shoreline Wetland Vegetative Establishment

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indicators.

The upper critical value for soil salinity in Texas's shorelines, wetlands, and estuaries would be an EC value of 16 or, parts per thousands (ppt) of 18 or greater. The lower end value for soil salinity is not critical. Soil salinity ranges for specific soil mapping units found in Texas's shorelines, wetlands, and estuaries can be located in the Physical And Chemical Properties Of The Soil tables in published soil surveys.

Sulfidic Material

Sulfidic materials are waterlogged mineral or organic soil materials that contain 0.75% or more sulfur (dry weight), mostly in the form of sulfides. Sulfidic materials accumulate in a soil that is permanently saturated, generally with brackish water. Under natural undisturbed conditions, sulfates are biologically reduced to sulfides as the soil materials accumulate. If the soil is drained, providing increased aeration, the sulfides oxidize and form sulfuric acid.

The acid reacts with the soil to form iron and aluminum sulfates. The pH, which may be normally near neutrality before drainage, decreases dramatically and may drop to below 3.

Drained or excavated marsh soils that contain large amounts of sulfides commonly have yellow efflorescences of the mineral jarosite on the exterior of clods. Another common method of detecting excess oxidizable sulfides (Soil Survey Staff, 1975) is to measure pH before and after soils are incubated at field capacity. If the decrease in pH after incubation is large, significant sulfides are probably present.

To determine the lower-end critical value for sulfidic material, two indictors are normally used. If an oxidized soil has a pH of ≤ 4.0, and/or has the present of yellow jarosite mottles on exposed clods, then sulfides are probably present and a laboratory determination of sulfur content may be required if precise levels are required. If a laboratory sulfur analysis is conducted, a value of .5% sulfur (dry weight) is considered to be the lower end critical value.

Bulk Density

In an upland mineral soil, the mineral content can comprise about 50% of the volume and have a density of 2.60 to 2.75 g/cm^3 of solids. The remaining volume of the mineral soil contains pore space and about 1 to 5% organic matter.

Soil density, expressed as mass of dry mineral and organic material per bulk volume of soil, is approximately 1.25 to 1.45 g/cm^3. For the purpose of establishing a critical low end value, shorelines, wetlands, and estuary soils with bulk densities ≤ 0.2 g/cm^3 would require special consideration. The upper end bulk density value is not critical.

Bulk density ranges for specific soil mapping units found in Texas's shorelines, wetlands, and estuaries can be located in the *Physical And Chemical Properties Of The Soil* tables in published soil surveys.

Soil and Geomorphologic Elements

Elements	Upper End Critical Value	Lower End Critical Value
n-Value	**None** Material is firm. Will not flow when squeezed in hand	**1.0** Material is very fluid. Flows easily when squeezed leaving hand empty
Texture	**Gravel, fragmented shell, or coarse sand** Material is loose and single grained	**Peat, muck-peat, fibric or hemic material** Materials are soft, fibrous, spongy and light weight
Soil Reaction (pH)	**8.5** pH indicator reaction or, presence of white salt crystals or, $CaCO_3$ concentrations	**4.5** pH indicator reaction, or presence of yellow jarosite mottles on surface
Soil Salinity (EC)	**16** EC meter or pH > 8.5, or salt crystals present on surface, or CaCo3 concentrations	**None** pH indicator reaction, or presence of yellow jarosite mottles on surface
Sulfidic Material Present	**Not critical** No field indicators	**4 (pH)** pH indicator reaction or yellow jarosite mottles present or air-dried sample becomes more acidic or hydrogen peroxide (H_2O_2) oxidation test
Bulk Density	**Not critical** Mineral materials- Consolidated, firm, plastic, or slightly fluid	**.2 g/cm^3** Organic materials - Unconsolidated, nonplastic, friable or very fluid

Hydrologic and Meteorologic Elements

When determining site suitability for vegetative consideration, tidal fluctuations (water depth), salinity, and wave climate are the principle considerations in choosing the appropriate plant species and planting methods. The following are general guide lines for making field estimates in the absence of data.

Tidal Inundation (water levels)

To estimate tidal elevations, consult local tide tables and make site observations during low water and high water periods. Make these observations during calm periods when waves are low and there are no local storm fronts. Use reference staketo delineate the tidal zone, that is, the mean low water and mean high water. Consider the midpoint between the high and low stakes to be mean tide level. Tide tables can be obtained from the U.S. Coast Guard, U.S. Geological Survey, and the National Oceanic and Atmospheric Administration (NOAA).

Critical lower end value for water depth for most emergent wetland species is -1.5 feet MSL. For specific species-water depth ranges, consult the list of common shorelines, wetlands, and estuary species found in the Vegetative Design Summary Table located in the Vegetative Planning section of this document, or use other local references.

Water Salinity

Water and substrate salinity will greatly influence site suitability and the choice of plant species. If specific information is not available, salinity can be estimated using the following general guidelines. Water begins to taste salty at about 3 ppt. Seawater contains about 33 ppt. Waters in bays and estuaries will have salinity lower than seawater because of the influence of freshwater. Salinities greater than seawater are likely to be encountered only in areas where circulation is poor and where evaporation rates and temperatures are high.

If water salinity is determined using a portable salinometer, caution must be taken that conditions represent normal or predominate site conditions. Salinity values are generally valid for only short periods and values can fluctuate drastically with changing moisture and weather conditions. The upper end critical value for Texas shorelines, wetlands, and estuaries is 33 ppt, while the lower end critical value is 0 ppt.

The Vegetative Design Summary Table located in the Vegetative Planning section gives the salinity and water level ranges for a number of common shoreline, wetland, and estuary plants.

Wave Climate

It is generally held that vegetation will successfully control erosion only in areas which are exposed to low and moderate wave energy.

It is a complex task to describe wave environments in which vegetative stabilization has been effective. There are many physical and biological variables which must be acknowledged when comparing wave climate to plant survival. Variables such as tidal coincident, wave energy, and shoreline contours will greatly vary in the stress placed on a planting. Also, the ability of a planted area to withstand wave stress will depend upon its growth stage, density, vigor, and overall width.

To date, site suitability can be described only in qualitative terms. The only descriptive information of wave climate is fetch (the distance the wind blows over open water to create waves). Fetch is one factor which influences wave generation; however, wind speed, wind duration, and water depth are also critical determinants of wave characteristics in shallow water. From limited available data and field experience a 1 foot wave height, in the absence of any frontal shoal protection, is the upper-end critical value for wave energy. This limit is arbitrary and is intended only as a general conservative guide.

Summary Table

Hydrologic and Meteorologic Elements

Elements	Upper End Critical Limit	Lower End Critical Limit
Water Depth	**None** See vegetative summary table for plant species and water depth ranges	**- 1.5 ft MSL-** Better suited to submerged or floating plant species
Water Salinity	**> 33 ppt** Extremely saline habitat See vegetative summary table for plant species and water salinity ranges	**0 ppt** Fresh habitat See vegetative summary table for plant species and water salinity ranges
Wave Height (Any Source)	**1.0 ft.** Wave stilling devices should be considered	**None** No wave stilling device needed
Fetch Length (Average)	**≥ 0.5 miles** (In absence of mud shoal front) Wave stilling devices should be considered	**None** No wave stilling device needed

Bank Configuration

A final consideration with respect to wave climate is the slope of the planting area itself. Waves tend to dissipate their energy over a short distance when meeting an abrupt shoreline. On a gradual sloping shoreline, wave energy tends to be dissipated over a longer distance. To dampen wave impact, planting areas should have a slope of 1 vertical to 6 horizontal or flatter. Above-water and below-water bank configuration critical values are provided in the Summary Table at the end of the section.

SUMMARY TABLE

GEOLOGIC ELEMENTS

ELEMENTS	UPPER END CRITICAL VALUE	LOWER-END CRITICAL VALUE
ABOVE WATER BANK CONFIGURATION	2:1 OR < ABRUPT SHORELINE - WILL REQUIRE STABILIZATION	NONE GRADUAL SLOPING SHORELINE POTENTIALLY STABLE
UNDERWATER BANK CONFIGURATION	6:1 OR < (IN ABSENCE OF MUD SHOAL FRONT) WAVE STILLING DEVICES SHOULD BE CONSIDERED	NONE POTENTIALLY STABLE

GRAZING AND NUISANCE SPECIES ELEMENT

In some areas, grass carp, nutria, muskrats, deer, and other grazing herbivores may destroy a planted area before it can become established. A number of exclosure devices have been tried throughout the years. Exclosure structures made of rigid material such as wire, polypropylene and laminated plastics have proven to be the most successful. However, on projects requiring large numbers of plants, nuisance exclosures can add a significant cost to the project.

Nutria exclosures would be advised if there is evidence of animal sighting, concentrated feeding activities such as digging for roots and rhizomes, or, in the absence of actual sighting, if vegetative areas are trampled and partially covered with mud, and feeding platforms and nest mounds are present.

SUMMARY TABLE

GRAZING AND NUISANCE ELEMENT

ELEMENTS	UPPER-END CRITICAL VALUE	LOWER-END CRITICAL VALUE
HERBIVORE GRAZING	NONE PRESENCE OF ANIMALS, FEEDING ACTIVITY, FEEDING PLATFORMS, NEST MOUNDS EXCLOSURES RECOMMENDED	NONE LIMITED OR NO GRAZING ACTIVITY OR NO ANIMALS OBSERVED EXCLOSURES NOT NEEDED

PLANT SPECIES ADAPTATIONS

A number of factors should be taken into consideration when selecting vegetative species for project establishment: 1) Plant species should match the wetland planting objectives; 2) Plant species should have the structural and physiological adaptations to perpetuate themselves under project conditions. Plant species selected for vegetative restoration projects should come from local ecotypes, or from selected (tested) plant cultivars, and have genetic similarities of species within the project vicinity; 3) Plant materials should be adequately available; and 4) The techniques for plant propagation should be established. Each of these criteria are discussed in detail in the following sections.

PROJECT GOALS AND OBJECTIVES

Plant species should be selected based on their morphological (form and structure) and physiological (system processes) adaptation to achieve project objectives. For example, species established to buffer high wave energies along shorelines should be rapid growing, stiff-stemmed, erect, and densely growing species. Species selected for sand dune stabilization should be able to tolerate blowing sand, burial, salt spray, droughty and nutrient poor soils. Project objectives and species capability should be closely matched.

SPECIES SELECTION

Certain species will be better suited to achieving a successful project than others, depending upon the planning objectives and type of shorelines, wetlands, and estuary to be revegetated. Desirable characteristics such as competitiveness, seed and tiller production, stem and root mass, tolerance to the site's soil conditions, hydrology, elevation, water depth, and salinity should be closely matched to the project site conditions. In general, plant species chosen should simulate closely nearby wetland species of similar types. The ecological impacts of using exotic vegetation are still not well understood and should be avoided in most areas.

PROPAGULE TYPES AND AVAILABILITY

Plant materials are generally obtained from two sources, a donor wetland site, or commercial nurseries. Use of donor wetlands to obtain seeds or young plants will eventually effect the health and vigor of the donor stand regardless of the care taken in frequency, spacing, and location of plant. removal. Removing plant materials from donor stands is not recommended unless commercial sources are not available. Nursery-grown stock is generally the most reliable and ecologically appropriate way to obtain plant materials. Private wetland nurseries are becoming more widespread and can custom propagate stock for wetlands. The most commonly used propagules are seed, seedlings, container plants, or bareroot vegetative stock. Vegetative specifications are used to tailor plant material quality to project needs and to establish project designs. These specifications can include number of pure live seed (PLS), specific plant age, stem height, extent of root development, or container size. Additional requirements such as climatic hardening and/or salt hardening are common.

PROPAGULE ESTABLISHMENT

Seeds are the least expensive to purchase and plant as they are generally broadcast on saturated surfaces with little or no seedbed preparation. However, seed sources for most shorelines, wetlands, and estuary species are scarce and unreliable. Container stock is the most expensive but provides the most reliable means of vegetating a wetland site. Gallon size containers of plant materials is fairly common and has proven to be a highly successful transplant. However, gallon containers pose significant limitations in transporting and handling large numbers of plants to the planting site. Tube planters, flats, or other similar smaller containerized materials needs but have generally been untested. Barerooted propagules such as vegetative plugs, rhizomes, tubers and other plant parts represent an intermediary between seed and container stock, both in terms of cost per unit and in survival potential.

The time of planting is regionally and species specific and is critical to the initial survival of the plant materials. Losses from elements of concern. Seed should remain stored in cool conditions away from the site until planting is to be made. Container and bareroot stock should be shaded and kept moist at all times. Planting dates other than those listed in the Vegetative Design Limit Parameter Summary Table will be considered on a site specific basis by consultation with local specialists.

- Plant species are ranked in ascending order by salinity from fresh to saline, and by elevation (within salinity) from highest to lowest msl
- Salinity is expressed in parts per thousand (ppt)
- Elevations are expressed relative to mean sea level (msl)
  - +00 msl expression represents an undetermined elevation above mean sea level, that is, the plant species should grow at any elevation above msl (within the coastal zone) provided availability of adequate moisture.
  - +/- msl expression represents the area at, or very near (plus or minus slightly) mean sea level elevation
- Propagation material is expressed as SS (single stems, bare root propagules), CO (container grown propagules), SP (stolon or rhizome propagules), and SE (seed)
- Spacing of plants within the row will vary according to site needs and growth habit of the selected species. Generally, the spacing for the listed tree species is 6 - 8 feet on center, shrub spacing is 2 - 6 feet on center, and the spacing for (SS, CO, and SP) herbaceous species 0.5 - 2 feet on center. The number of rows needed will also vary according to site conditions; however, a minimum of 4 rows of herbaceous material is recommended.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

A Project Site Evaluation Worksheet incorporating the site planning critical elements discussed in Section 1, Site Planning Considerations, is on the last page of this Technical Note. The Site Evaluation Worksheet is designed to assist project coordinators in assessing site conditions prior to developing a project installation design and prior to making a plant species selection.

OPERATION AND MONITORING

Monitoring is necessary to measure project success, both in the short and long term. In addition, monitoring can also provide the mechanism to identify the need for mid-course correction if project goals established during the planning stages are not being met. Specific monitoring and management objectives and their related activities will vary depending on wetland or shoreline type, design, and desired functions. Clear and concise criteria, both quantitative and qualitative, should be established to provide effective measures of success.

Critical to successful monitoring is the establishment of baseline conditions. Baseline information should be measured and recorded for each project goal to be monitored. The frequency of monitoring will vary, depending on the goal and the probability that corrective management action will be required. In general, more frequent monitoring is required the first two years immediately following project completion and less frequently thereafter.

There are a number of common elements that will provide a reasonable measure of the success of the project when compared to baseline conditions. Plant survival and productivity are standard dependent variables in determining site adaptability. A measurement of a plant species' ability to collect sediments, resist wave energies, and provide effective soil stability to the project site are additional types of dependent variables sometimes measured depending on project objectives. Salt tolerance, water depth, insects, disease, grazing pressure, and climatic variability are several independent variables commonly measured.

It is critical that a project monitoring plan be developed prior to project installation, that baseline (pre-treatment) information be obtained, and that systematic monitoring (post-treatment) be conducted.
Lastly, when many shoreline, wetland, and estuary projects are conducted in the same general region, it is important to standardize the monitoring methods used. The use of consistent monitoring methods allows information from different sites to be compared and possibly combined. The information is essential for developing better wetland project designs and construction techniques for the region.